Journal of Cardiology (2009) **54**, 282—288

CARDIOLOGY
Official Journal of the Japanese College of Cardiology
www.elsevier.com/locate/jjcc

ORIGINAL ARTICLE

Impact of intraoperative transesophageal echocardiography in cardiac and thoracic aortic surgery: Experience in 1011 cases

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Received 17 February 2009; received in revised form 16 May 2009; accepted 4 June 2009
Available online 18 July 2009

KEYWORDS
Cardiovascular surgical procedures;
Coronary artery bypass surgery;
Intraoperative monitoring;
Transesophageal echocardiography

Summary
Background: Although intraoperative transesophageal echocardiography (IOTEE) has been widely used in cardiovascular surgery, the exact incidence of abnormalities detected by IOTEE in each type of surgical procedure is still unclear. The aim of this study was to review our experiences of IOTEE, in patients who underwent different types of cardiovascular surgery and to evaluate the clinical usefulness of IOTEE.
Methods and results: Our database of 1011 consecutive patients, who underwent cardiovascular surgery and IOTEE monitoring was reviewed. The incidence of abnormal findings was 115 of 1011 patients (11.4%), and the highest incidence was the appearance of new wall motion abnormalities after cardiopulmonary bypass. These findings influenced surgical decision-making in 59 of the evaluated 1011 patients (5.8%).

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0914-5087/$ — see front matter
doi:10.1016/j.jjcc.2009.06.001

Conclusions: IOTEE provides important intraoperative and postoperative information that may influence surgical decision-making in various cardiovascular surgeries.

Introduction

Intraoperative transesophageal echocardiography (IOTEE) has been widely used in cardiovascular surgery and the favorable influence of IOTEE on perioperative decision-making has been well recognized [1—4]. Before cardiac surgery, IOTEE can reveal previously undiagnosed lesions and pathology, and allow immediate correction. Abnormal findings such as new left ventricular (LV) wall motion abnormalities, residual valvular leakage, and aortic complications can be detected after cardiopulmonary bypass (CPB). Although IOTEE has been introduced during different types of cardiac or aortic surgery and its usefulness has become evident, the incidence of abnormalities that are detected during the perioperative period by TEE is unknown. The aim of this study was to review our experience of 1011 patients who underwent different types of cardiac and thoracic aortic surgical procedures and to evaluate the clinical usefulness of IOTEE.

Methods

We reviewed our departmental database for all patients who underwent elective or urgent cardiovascular surgery in Yamaguchi University Hospital and who were monitored with IOTEE between January 1998 and December 2007. A large majority of the IOTEE examinations were performed before, during, and after CPB. Informed consent, approved by the institutional review board, was obtained from either all patients or their family members before surgery.

IOTEE

A multiplane TEE probe (5 MHz) interfaced with a commercially available ultrasound scanner (SSD-2200, SSD-5500, or α5, ALOKA Ltd., Tokyo, Japan), was inserted by cardiologists or anesthesiologists after the induction of general anesthesia. Images were obtained before sternotomy, before undergoing CPB, after weaning from CPB, and when warranted during the course of surgery. All images were recorded on S-VHS videotapes or digital video discs and stored on a digital database for off-line review and analysis. An electrocardiogram was recorded continuously throughout the procedure. The IOTEE procedure was performed according to the guidelines for perioperative TEE by the American Society of Echocardiography (ASE) and the Society of Cardiovascular Anesthesiologists (SCA) [5,6]. The cardiologists who performed IOTEE during the study had at least 3 years of TEE experience.

Study design

Before, during, and after CPB, we evaluated the incidence of the events listed as follows: (1) appearance of a new wall motion abnormality; (2) perigraft leakage after transluminal endovascular stent graft repair; (3) intimal tears or flaps of the aorta; (4) valve dysfunction; (5) difficulty in coming off CPB; and (6) other events.

Results

There was no failure of insertion of the TEE probe in any patient. A total of 1079 patients underwent cardiac or thoracic aortic surgery, and IOTEE was performed in 1011 of these. There was no complication related to manipulation of the echo probe during IOTEE. IOTEE was performed in 360 patients who underwent coronary artery bypass graft surgery (CABG), 229 valve only surgery (73 mitral valve, 109 aortic valve, and 47 combined valve), 169 aorta replacement surgery, 66 transluminal endovascular stent graft repair, 99 combined procedure (39 combined valve-aorta replacement surgery, 24 combined CABG-valve surgery, 14 combined valve-other procedure, 10 combined CABG-aorta replacement surgery, 9 combined CABG-other surgery, 3 combined valve-CABG-aorta replacement-other surgery) and 88 patients undergoing miscellaneous cardiac or thoracic aortic procedures (Fig. 1). A total of 115 of 1011 patients (11.4%) had abnormal findings as listed in Table 1. The most frequent events were occurrence of a new wall motion abnormality post-CPB, followed by perigraft leakage after transluminal endovascular stent graft repair. The IOTEE information influenced the cardiac surgical

Table 1 Abnormal findings detected by intraoperative transesophageal echocardiography (115 findings).

Occurrence of a new wall motion abnormality	42 (4.2%)
Perigraft leakage after transluminal endovascular stent graft repair	16 (1.6%)
Intimal tears or flaps of aorta	14 (1.4%)
Valve dysfunction	12 (1.2%)
Difficulty in weaning from cardiopulmonary bypass	6 (0.6%)
Other	25 (2.5%)

Table 2 Altered surgical management (59 alterations).

Additional aortic stenting	12 (20%)
Intra-aortic balloon pump/percutaneous cardiopulmonary system insertion	11 (19%)
Vascular repair	8 (14%)
Valve repair	8 (14%)
Revision of graft	6 (10%)
Other	14 (24%)

decision-making in 59 patients (5.8%) (Table 2). The percentage of new events detected by IOTEE in each surgical intervention is demonstrated in Fig. 2. The number of events detected by IOTEE in each cardiac or thoracic aortic procedure is listed in Table 3. In all procedures, except for transluminal endovascular stent graft repair, the appearance of a new wall motion abnormality was detected most frequently by IOTEE throughout the surgery. In Fig. 3, the number of combined procedures is shown for each year. Combined procedures such as CABG and valve repair gradually increased for 10 years. The year-related change of incidence of abnormal findings is shown in Fig. 4. Between 1998 and 2005, the ratio of abnormal findings gradually increased, however in 2006 and 2007, the ratio decreased (4%).

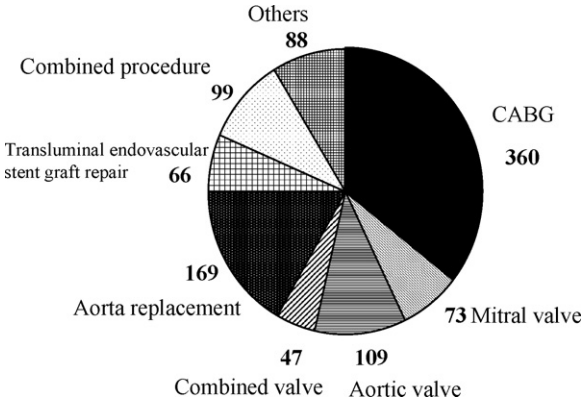

Figure 1 Overview of surgical procedures in 1011 patients who had intraoperative transesophageal echocardiography (IOTEE) performed during cardiovascular surgery. CABG, coronary artery bypass grafting.

Patients undergoing isolated CABG

New isolated regional wall motion abnormalities were detected in 17 of 360 (4.7%) patients undergoing CABG-only surgery (Table 3). In 15 of 17 patients, wall motion abnormalities recovered during close observation, and revision surgery on the coronary artery bypass graft was performed in 2 of the CABG patients (0.6%). After revision of surgery, wall motion abnormality recovered in two cases.

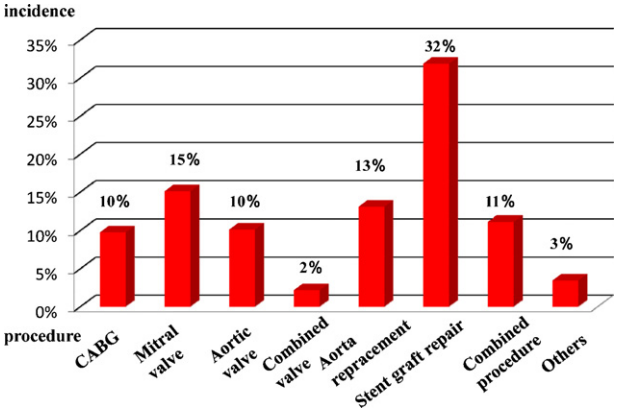

Figure 2 The percentage of abnormal findings detected by intraoperative transesophageal echocardiography (IOTEE) in each surgical group. CABG, coronary artery bypass grafting.

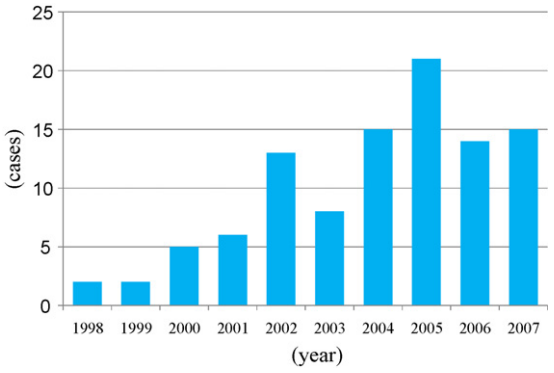

Figure 3 The number of patients who underwent combined procedures in each year. Combined procedures such as coronary artery bypass grafting and valve repair gradually increased for 10 years.

Table 3 The number of events detected by intraoperative transesophageal echocardiography.

Event	Procedure							
	CABG (360)	Mitral valve only (73)	Aortic valve only (109)	Combined valve (47)	Aorta replacement (169)	Stent graft repair (66)	Combined procedure (99)	Others (88)
Occurrence of a new wall motion abnormality	17	4	5	1	9	0	5	1
Perigraft leakage after transluminal endovascular stent graft repair	(−)	(−)	(−)	(−)	(−)	16	(−)	(−)
Intimal tears or flaps of aorta	6	0	1	0	4	2	1	0
Valve dysfunction	0	5	3	0	1	0	3	0
Difficulty in weaning from CPB	2	1	0	0	1	0	1	1
Other	10	1	2	0	7	3	1	1
	35 (10%)	11 (15%)	11 (10%)	1 (2%)	22 (13%)	21 (32%)	11 (11%)	3 (3%)

CABG, coronary artery bypass graft surgery; CPB, cardiopulmonary bypass.

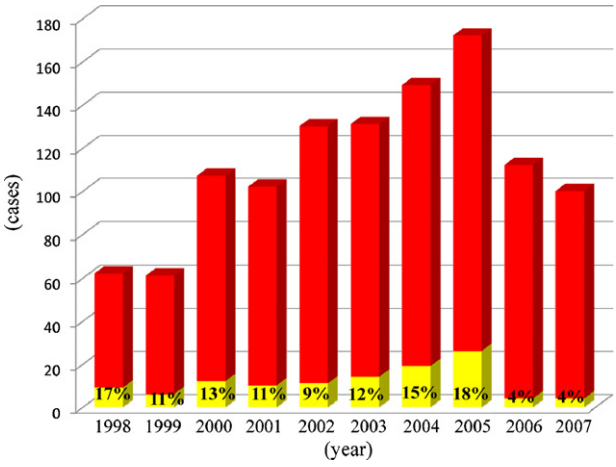

Figure 4 The number of intraoperative transesophageal echocardiography (IOTEE) and percentages of abnormal findings detected by IOTEE (yellow bar) in each year. Between 1998 and 2005, the ratio of abnormal findings gradually increased. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of the article.)

Patients undergoing aorta stent surgery

Transluminal endovascular stent graft repair was performed in 19 patients with distal aortic arch aneurysm, 21 patients with descending thoracic aortic aneurysm, 25 patients with dissection of the aorta (Stanford type B), and 1 patient with aortic invasion of lung cancer. The percentage of abnormal IOTEE findings in the aorta stent surgery group was 32%, and this was the highest among the surgical groups (Fig. 2). The majority of new abnormalities were perigraft leakage from the stent graft (76% of abnormal findings in the aorta stent surgery group; Table 3, Fig. 5). Additional aortic stenting was needed in 12 patients who underwent aorta stent surgery.

Patients undergoing valve surgery

Mitral valve-related procedure

A total of 132 cases of mitral valve-related procedures (73 mitral valve only, 19 mitral + aortic valve, 22 mitral + tricuspid valve, 9 mitral valve + CABG, 7 mitral valve + aorta, 2 mitral + aortic + tricuspid valves) were performed. In six patients, information obtained from IOTEE resulted in a return to CPB after initial weaning from CPB. Severe mitral regurgitation was still present after mitral valve repair, and additional repair or mitral valve replacement was performed. In one patient, although severe mitral regurgitation was detected

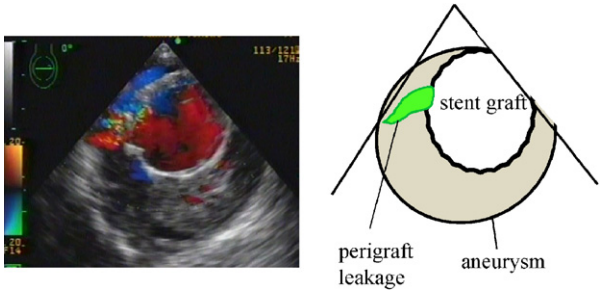

Figure 5 Perigraft leakage was observed immediately after deployment of stent graft in thoracic aortic aneurysm. After 20—30 min observation, thrombus formation was observed in the aneurysm and the leakage disappeared.

after CPB, systolic anterior motion of the mitral anterior leaflet (SAM) after CPB was revealed. This mitral regurgitation was thought to be caused by obstruction of the LV outflow tract (Fig. 6a) induced by the small chamber size of the LV, tachycardia, and LV hyperkinetic wall motion. In this case, after stopping infusion of the inotropic agent and increasing LV volume, severe mitral regurgitation disappeared as improving tachycardia and obstruction of the LV outflow tract (Fig. 6b).

Aortic valve, combined valve procedure

Although the most frequent abnormal findings detected by IOTEE during aortic or combined valve procedure were new wall motion abnormalities, the incidence was less than in mitral valve procedures (Table 3).

Discussion

We evaluated the clinical utility of IOTEE by reviewing our experience of a series of 1011 patients who underwent different types of cardiac and thoracic aortic surgical procedures. In this study, we demonstrated that TEE before and during surgery influenced surgical decision-making in 59 of the 1011 patients (5.8%) evaluated (Table 2). A previously published large-scale study in 12,566 patients, reported that the pre- and post-CPB TEE examinations influenced surgical decision-making in 7.0 and 2.2% of cases, respectively [7]. Although we did not evaluate pre- and post-CPB separately, the incidence of IOTEE findings that influenced the surgical decision-making was comparable to the data provided by Eltzschig et al. [7]. In our study, transluminal endovascular stent graft repair surgery accounted for 6.5% of all surgeries. Although a few studies have been reported concerning the usefulness of IOTEE in aorta stent surgery for an aortic aneurysm or aortic dissection [8], the incidence of abnormal IOTEE findings in this type of surgery was found to be the highest among the surgical groups (Fig. 5). In contrast to open cardioaortic surgery, endovascular stent graft repair surgery is often performed percutaneously and surgeons cannot view the operative field directly. Because TEE is the only feasible method for visualizing the aortic arch and the thoracic descending aorta as well as the position of the stent graft intraoperatively, IOTEE should be an essential monitoring device for transluminal endovascular stent graft repair surgery. We performed IOTEE on almost all patients who underwent CABG. The routine use of IOTEE during cardiac surgery remains controversial, especially for lower risk patients scheduled only for CABG [9]. Previous studies reported that revision of the graft was performed in 0.8% of patients who underwent CABG [7,10]. In our study, 17 of 360 patients (5%) were found to have a new wall motion abnormality post-CPB. Most of these patients did not need a return to CPB or an addi-

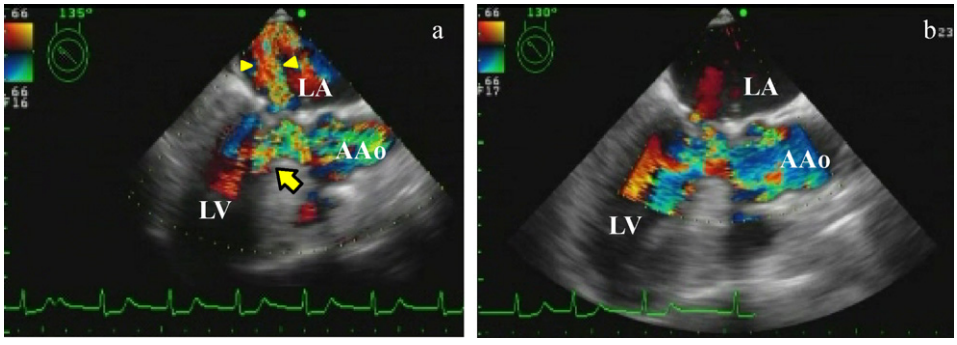

Figure 6 (a) Severe mitral regurgitation (arrow head) and obstruction of the left ventricular outflow tract with mosaic color flow (arrow) detected by intraoperative transesophageal echocardiography (IOTEE). (b) Obstruction of the left ventricular outflow tract improved after volume loading and stopping catecholamine, and then mitral regurgitation disappeared. AAo, ascending aorta; LA, left atrium; LV, left ventricle.

tional graft, but needed observation for 20—30 min, when wall motion abnormalities resolved. A revision of the previously placed graft was required in two cases (0.6%) and this percentage was comparable to the data reported previously [7,9]. Thus to detect myocardial ischemia associated with possible graft kinking, coronary spasm or air embolism, IOTEE is desirable in the patient who is undergoing CABG. On the other hand, the necessity for IOTEE in mitral valve surgery is established. According to ASE/SCA guidelines for performing a comprehensive intraoperative multiplane TEE examination [6], the use of IOTEE is strongly recommended for guiding surgical decision-making by providing insight into the mechanism of mitral disease before repair [11]. IOTEE is useful for not only providing the information before CPB, but also for detecting the presence of residual regurgitation and its mechanism after CPB. In our study, 7 of 132 cases who underwent mitral valve-related surgery had residual mitral regurgitation detected, and 6 patients returned to CPB for additional repair. In one case, severe mitral regurgitation with SAM was detected immediately after CPB (Fig. 6a). The incidence of SAM and LV outflow tract obstruction (LVOTO) were reported to range from 2 to 16% [12—14], and was recognized to be not inconsiderable. In our case, we thought that mitral regurgitation was attributed to SAM and LVOTO, and then we loaded the LV volume and stopped catecholamine, and mitral regurgitation disappeared (Fig. 6b). Maslow et al. [14] reported that TEE analysis of the mitral valve apparatus could identify patients likely to develop SAM/LVOTO after mitral valve repair for myxomatous valve disease. According to their report, the anterior leaflet length/posterior leaflet length contributing to the mitral valve was significantly lower among patients who developed SAM/LVOTO than among those who did not. Although these indices may be useful for predicting SAM/LVOTO before CPB, intraoperative monitoring by TEE is necessary for evaluating mitral regurgitation during surgical procedures. Recently, real-time three-dimensional (3D) TEE was introduced into the clinical setting, and its usefulness for diagnosis of mitral valve lesions was reported [15—18]. Real-time 3D IOTEE will allow for the development of virtual surgical programs and provide a means to assess mitral lesions in a circumferential direction and allow surgical decision-making especially for mitral valve prolapse. New technological developments in 3D IOTEE may take the place of 2D IOTEE in routine intraoperative monitoring for cardiovascular surgery.

A previous study reported that the complications associated with TEE were severe odynophagia, dental injury, endotrachial tube malpositioning, upper gastrointestinal hemorrhage, esophageal perforation, and so on [19]. In our study, there was no major complication over 10 years. Because experienced cardiologists operated the TEE probe carefully, especially using a small probe (9 mm in diameter), we could overcome complications related to the TEE procedure.

Conclusion

In our experience of 1011 cases who underwent intraoperative TEE, the incidence of abnormal findings was 11.4%. These findings influenced surgical decision-making in 5.8% of all evaluated patients. Thus IOTEE provides valuable information to aid in reducing surgical complications and influences surgical decision-making in a large variety of cardiac or aortic surgical procedures.

Acknowledgments

We appreciate the technical assistance of many colleagues in performing echocardiographic recording: Nobuaki Tanaka MD, Shiro Ono MD, Yasuaki Tomochika MD, Takashi Tone MD, Aiko Muro MD, Hideki Kunichika MD, Takashi Fujino MD, Mitsuo Iwatate MD, Taketo Tanigawa MD, Kayo Omura MD, Takayuki Hisaoka MD, Kazumi Kimura MD, Nozomu Harada MD, Jinyao Liu MD, Yoko Sawa MD, Eizo Akagawa MD, and Ryo Hashimoto MD.

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